

THE MARS MICROBEAM RAMAN SPECTROMETER – AN IMPROVED ADVANCED BRASSBOARD.

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Introduction: An advanced brassboard (ADBB) of the Mars Microbeam Raman Spectrometer [1,2,3,4] is being developed. The probe (Figure 1) and spectrograph have been redesigned with improved optics and the electronics have been miniaturized. The modified optical design in the probe and spectrograph provides better spectral resolution than the previous model and enables the probe design to be more compatible with robotic arm deployment. The CCD detector is now cooled thermoelectrically in anticipation of eventual terrestrial field testing of the instrument.

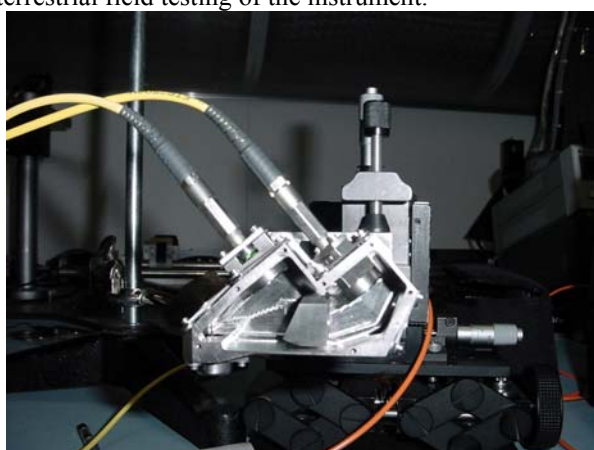


Figure 1. Probe, MMRS Advanced Brassboard

Performance test results: Here we describe significant improvements in spectral quality and detection sensitivity that the new optics provide.

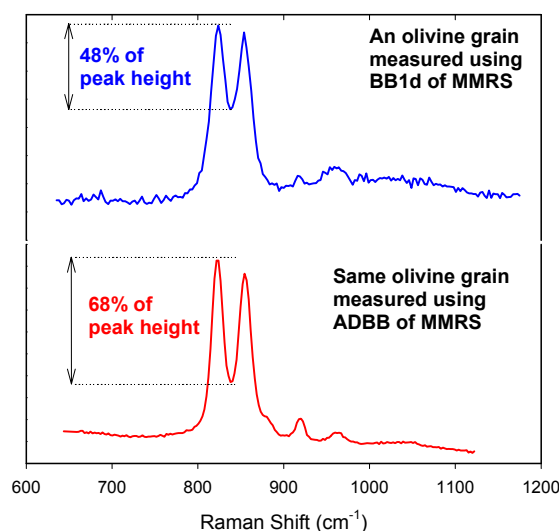


Figure 2. improved spectral resolution

Detection sensitivity -- Based on measurements on a set of standard common minerals (quartz, feldspar,

olivine, pyroxene and calcite), ADBB has a detection sensitivity $\sim 40\%$ that of our state-of-the-art laboratory Raman system. The detection sensitivity is thus twice that of the previous MMRS brassboard [BB1d, 4].

Spectral resolution and spectral range – The ADBB also has improved spectral resolution. Fig. 2 shows the same olivine sample measured using BB1d and ADBB. The separation of the two Raman peaks in the spectrum of a standard olivine has increased from 48% to 68%. In designing a miniaturized spectrograph, spectral resolution and spectral range are contradictory parameters that work against each other. Even with its improved spectral resolution, ADBB maintains the required spectral range ($207\text{--}4325\text{ cm}^{-1}$), which covers the fundamental vibrational bands of minerals, OH, H₂O, and organic species.

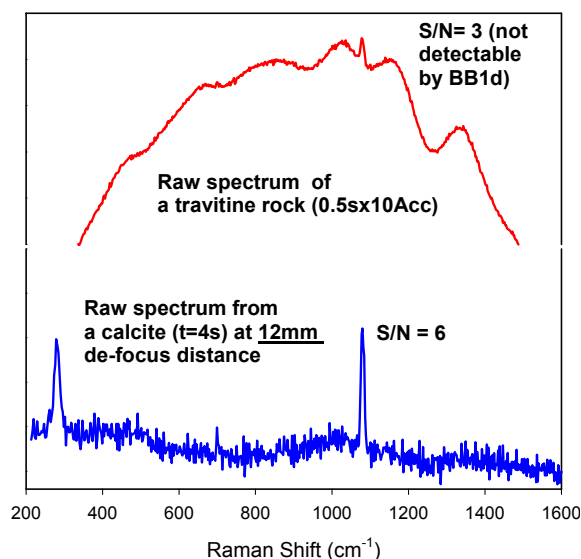


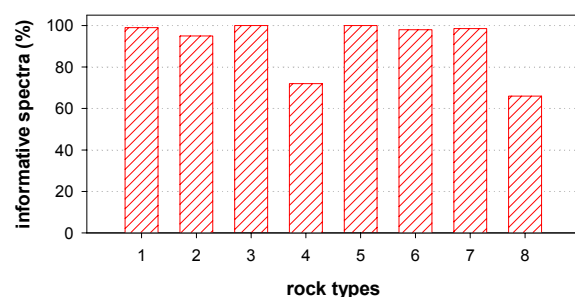
Figure 3. Detection of “fluorescent” species (upper) and Depth of Sampling Filed (DSF)(lower)

Detection of Raman signal from “fluorescent” samples – Photoluminescent (including fluorescent) emission stimulated by the excitation laser can provide a high background under the spectra of some minerals, and sometimes lower the signal-to-noise (S/N) to the extent that Raman peaks cannot be detected. Changing the wavelength of the excitation laser can improve detection for one sample, but may induce photoluminescence at an inconvenient wavelength in another sample. Especially, some terrestrial sedimentary rocks photoluminesce. The smaller beam size of ADBB improves the Raman-to-photoluminescence S/N ratio.

The upper spectrum in Figure 3 was taken from a sample of travertine from which BB1d gave no evident carbonate signal, but ADBB gives a strong enough signal (S/N level ~ 3) to observe the carbonate mineral and identify it as calcite.

Depth of Sampling Field – The MMRS will be deployed by the robotic arm of a rover or a lander or used as a stationary analyzer for characterization of materials delivered to the host platform and perhaps modified by chemical experiments. Used either way, sample surfaces are likely to be rough and uneven. The design of the MMRS eschews automatic focusing for the sake of system simplicity. This requires that the probe have a substantial depth of sampling field (DSF), and the improved optics of ADBB provide this. The lower spectrum in Figure 3 was taken from a calcite sample located at 12 mm away from the focal plane of the ADBB probe. A S/N of 6 for the major peak of calcite was obtained in a 4 second integration time. A ~ 12 mm DSF was obtained from a light green olivine, but only a 2 mm DSF was obtained for a very dark pyroxene. The DSF value also decreases as mineral grain size decreases so that light scattering becomes more important[4].

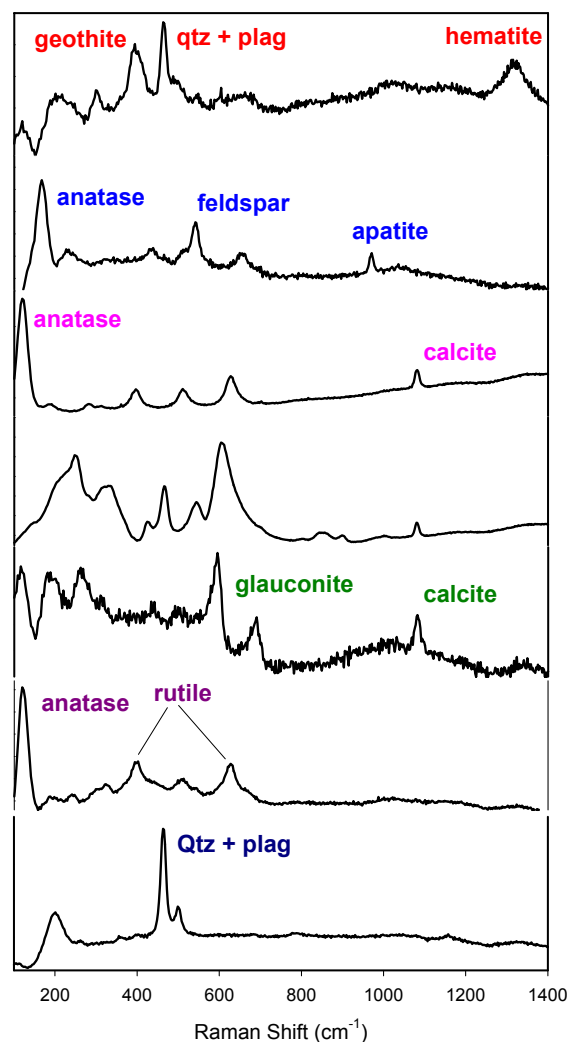
Figure 4. percentage of informative spectra from the point-counting Raman measurements on 8 rocks



Point-counting rock measurements – Fifteen sets of point-counting Raman traverses [5] were done on 8 rock samples. Figure 4 shows the percentage of informative spectra (i.e., spectra with definitive Raman peaks of minerals, H₂O, or organic C) obtained from these measurements. These measurements were made using fixed laser power, fixed measurement time, and no laser focus adjustment after the first sampling point. More than 95% informative spectra were obtained from fresh or lightly altered igneous rocks. Somewhat lower fractions (72% and 66%) of definitive spectra were obtained from two rocks with substantial photoluminescent backgrounds. Figure 5 shows spectra obtained on samples from deep ocean drilling cores (801B-42R1-56-60 and 801C-15R2-53-56-615.6). Original igneous minerals and minerals produced by low temperature metamorphic alteration, and sedimentary deposition are represented.

Conclusion: The improved optical performance of Advanced Brassboard will eventually enable a definitive, terrestrial field test of the ability of the anticipated Mars Microbeam Raman Spectrometer to do field mineral characterization.

Figure 5. Typical Raw Raman spectra obtained from point-counting measurement taken on samples of deep ocean drilling cores.



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References:

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- [2] Haskin et al., (2001), LPS XXXII, Abstract #1705.
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- [5] Haskin et al., (1997), *JGR*, **102**, 19293-19306.